REMARKS/ARGUMENTS

Favorable reconsideration of this application, as presently amended and in light of the following discussion, is respectfully requested.

Claims 1-20 are pending in the above-identified application. Claims 1-10 have been amended to address informalities, and Claims 11-20 are added by way of the present amendment. Support for these amendments can be found at page 4, lines 6 to 11, page 13, lines 19 to 23 and page 17, lines 14-20, and Figs. 7 and 10, for example. Support for new Claims 11-20 can be found at page 10, line 24 to page 11, line 4 and page 11, line 18 to page 12, line 10, for example. No new matter is added.

In the Office Action, Claims 1-10 were rejected under 35 U.S.C. § 103(a) as unpatentable over Jang et al. (U.S. Publication No. 2004/0051134, herein "Jang").

Regarding the rejection of Claim 1 as obvious over Jang, that rejection is respectfully traversed by the present response.

By way of review, the present invention, as recited in independent Claims 1 and 13, is directed to a method for uniformly forming a high-k dielectric film on the substrate by controlling the residence time of the metal organic compound. The high-k dielectric film forming step includes a first step for forming nuclei of the high-k dielectric film on a surface of the substrate, and a second step for uniformly growing crystal grains of the high-k dielectric film from the nuclei.

The present invention can provide an increase in the residence time entailing an increase in the collision frequency of the metal organic compound molecules with the surface of the substrate and, as a result, nuclei of the high-k dielectric film are formed at a high areal density. The residence time of the metal organic compound of the first step is set to be longer than that of the second step. Due to the long residence time of the first step, the nuclei are formed on the surface of the substrate at a high areal density, as described in Fig. 9A. The residence time is set

to be shorter during the second step, and thus the grains grow uniformly and in relatively small and even sizes to thereby entail a uniform film having a reduced surface roughness owing to the high areal density of the nuclei formed on the surface of the substrate in the first step.

In contrast, Jang discloses that aluminum oxide is deposited by ALD (atomic layer deposition) to form a high-k dielectric for the interpoly dielectric layer of a non-volatile memory device. The ALD method of Jang includes four steps. The first step is to introduce a $Al(CH_3)_3$ precursor gas into a ALD chamber containing a pre-cleaned substrate and to chemiabsorb the precursor gas onto the surface of the substrate until the surface is saturated with Al atoms. The second step is to purge the chamber with an inert gas. The third step is to introduce an oxidizing gas and to oxidize the Al atoms until the surface is saturated with a monolayer of aluminum oxide. The fourth step is to purge an oxidizing gas and any undesired reactants with an inert gas. By repeating the four steps, a high-k thin film can be deposited, a single monolayer at a time.

The Office Action asserts that the first and the second steps of the present invention are disclosed in Jang, with the exception that the second residence time is shorter than the first residence time. However, this rejection is respectfully traversed on the grounds that the steps of the present invention are different from those of the cited reference.

Comparing the first and second steps of the present invention with the first and third steps of Jang, respectively, the steps are different from each other as follows.

First, in the present invention, the dielectric layer is deposited during both the first and the second steps, while the dielectric layer of Jang can be deposited only after completing the first step through the fourth step. That is, the metal organic compound and other processing gases, which are used for depositing the dielectric layer, are supplied to the processing chamber during both the first and the second steps of the present invention. Therefore, the dielectric layer is formed during the first step as well as the second step.

In contrast, in Jang, the process gases in the first and the third step are different from each other. During the first step of Jang, the surface of the substrate is saturated with the Al atoms by chemiabsorbing a pre-cursor gas onto the substrate. Then, during the third step of Jang, the Al atoms are oxidized by an oxidizing gas until the surface is saturated with a monolayer of aluminum oxide. The monolayer of aluminum oxide, which is a high-k dielectric layer, is not formed until completing these all steps.

Second, in Jang, there is no motivation to improve the surface roughness of the high-k dielectric layer by means of controlling the residence time. As described above, the present invention endeavors to provide a film forming method capable of reducing a surface roughness of a high-k dielectric film when forming the high-k dielectric film by CVD. The nuclei forming and the grain growth are affected by the residence time of the metal organic compound.

In contrast, in Jang, the surface of the substrate is saturated with the Al atoms at the first step and then the Al atoms are oxidized by an oxidizing gas at the third step. Therefore, the layer formed by these processes is expected to be flawless to produce a smooth surface. As a result, the dielectric film formed by the ALD method has a fine roughness, relative to conventional CVD methods. In an ALD method as described in Jang, the residence time does not affect the surface roughness in general. Therefore, the technical features of the present invention as recited in independent Claim 1 are not taught or suggested by Jang which discloses an ALD method as a deposition method of the high-k dielectric layer.

Inasmuch as the Office Action would correlate each of the first and the second steps in the present invention to all of the ALD steps in Jang taken as a whole (from the first step through the fourth step in Jang), that rejection is respectfully traversed by the present response.

In the first step of the present invention, multilayered nucleus islands are formed on the base film as shown in Fig. 9A. However, in Jang, a high-k thin film is deposited by repeating each of the ALD steps 1-4, a single monolayer is formed each time all of steps 1-4 are performed.

In addition, in the second step of the present invention, the grains of the high-k dielectric film are grown from the nuclei. The structure of the film formed during the first step is different from that of the film formed during the second step. However, in Jang, the same monolayers are formed each time by repeating all of ALD steps 1-4. Therefore, the resultant structures of the process recited in Claim 1 and Jang are different from each other.

The Office Action asserts that one of ordinary skill in the art would have been led to the recited residence time, pressure, flow rate and temperature through routine experimentation to achieve a desired rate of reaction and a desired dielectric thickness.[1] The Office Action also asserts that the selection of residence time, pressure, flow rate and temperature is obvious because it is a matter of determining optimum process conditions by routine experimentation with a limited number of species of result effective variables.[2]

However, a particular parameter must first be recognized as a variable which achieves a recognized result before the determination of the optimum or workable ranges of said variable might be characterized as routine experimentation (*In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977)).[3]

None of the cited references, including Jang, teaches or suggests how those parameters of the present invention, especially the residence time, are related to controlling a surface roughness of the high-k dielectric film. Consequently, those parameters of the present invention, especially the residence time, are not result-effective variables recognized by the cited art. In

[1] Outstanding Office Action at 2-3.
[2] Id.
[3] MPEP § 2144.05 citing In re Antonie.

addition, although an invention is realized by cooperation of a plurality of parameters, how or that the plurality of parameters cooperate and influence the deposition result is indeed not discoverable by routine experiments. Accordingly, it is respectfully submitted that those deposition parameters of the presently claimed invention are not results-effective variables, and it is respectfully requested that the parameters recited in independent Claim 1 be given patentable weight.

As discussed above, the cited references do not show the inventive features of the present invention as set forth in independent Claim 1 or independent Claim 13. Accordingly, it is respectfully submitted that the Claims 1 and 13 patentably distinguish over the cited references for at least the reasons discussed above.

It is also believed that Claims 2-12 and 20, directly or indirectly depending on amended Claim 1, and Claims 14-19, directly or indirectly depending on Claim 13, are allowable for the same reasons indicated with regard to Claims 1 and 13, respectively, as well as for their own features.

Consequently, in light of the above discussion and in view of the present amendment, the present application is believed to be in condition for allowance and an early and favorable action to that effect is respectfully requested.

Should Examiner Estrada deem that any further action is necessary to place this application in even better form for allowance, she is encouraged to contact Applicants' undersigned representative at the below listed telephone number.

Respectfully submitted,

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